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ABSTRACT

This study was designed to determine whether instructional treatments specifically designed to match identifiable learner characteristics can produce significantly better learning than mismatched instruction. Instructional treatments for geometry were developed to match learning patterns of individual students, using field-dependence and field-independence as the learner traits. A total of 89 suburban 3rd graders were tested with the Children's Embedded Figures Tests and were classified as either field-dependent or field-independent. They were then randomly assigned to one of three treatment groups: (1) instruction matched to field-independent cognitive style, (2) instruction matched to field-dependent cognitive style or (3) no instruction. After the instruction had been completed, four criterion tests developed and validated by the researcher were administered to the students. The data were analyzed in a trait by treatment (2 x 3) factorial analysis of variance. The findings indicated that there was a successful matching of trait and treatment in comparison to the control treatment in 3 cases and in comparison to the opposite treatment in 1 case. Results were interpreted as providing partial support for the theory that matching learner traits and instructional treatments can produce learning gains. (JMB)

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THE EFFECTS OF INSTRUCTIONAL DESIGNS MATCHED TO INDIVIDUAL DIFFERENCES IN COGNITIVE STYLES ON CONCEPT LEARNING: A TRAIT-TREATMENT INTERACTION STUDY

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ABSTRACT

To enhance learning of concepts, instructional treatments were specifically and systematically developed to match learning patterns of individual students, using field-articulation and conceptual-tempo cognitive styles as learner traits. A theoretical model of the optimization of learning was developed, involving information processing, instructional development, and evaluation of learning in relation to the matching of trait and treatment. A set of procedures was synthesized for determining instructional variables to match specific learning needs. Treatment variables involved attribute highlighting, example sequencing, and information density. Hypotheses of no difference between various trait-treatment combinations were rejected with a greater than chance occurrence, using suburban third-grade *S*s.

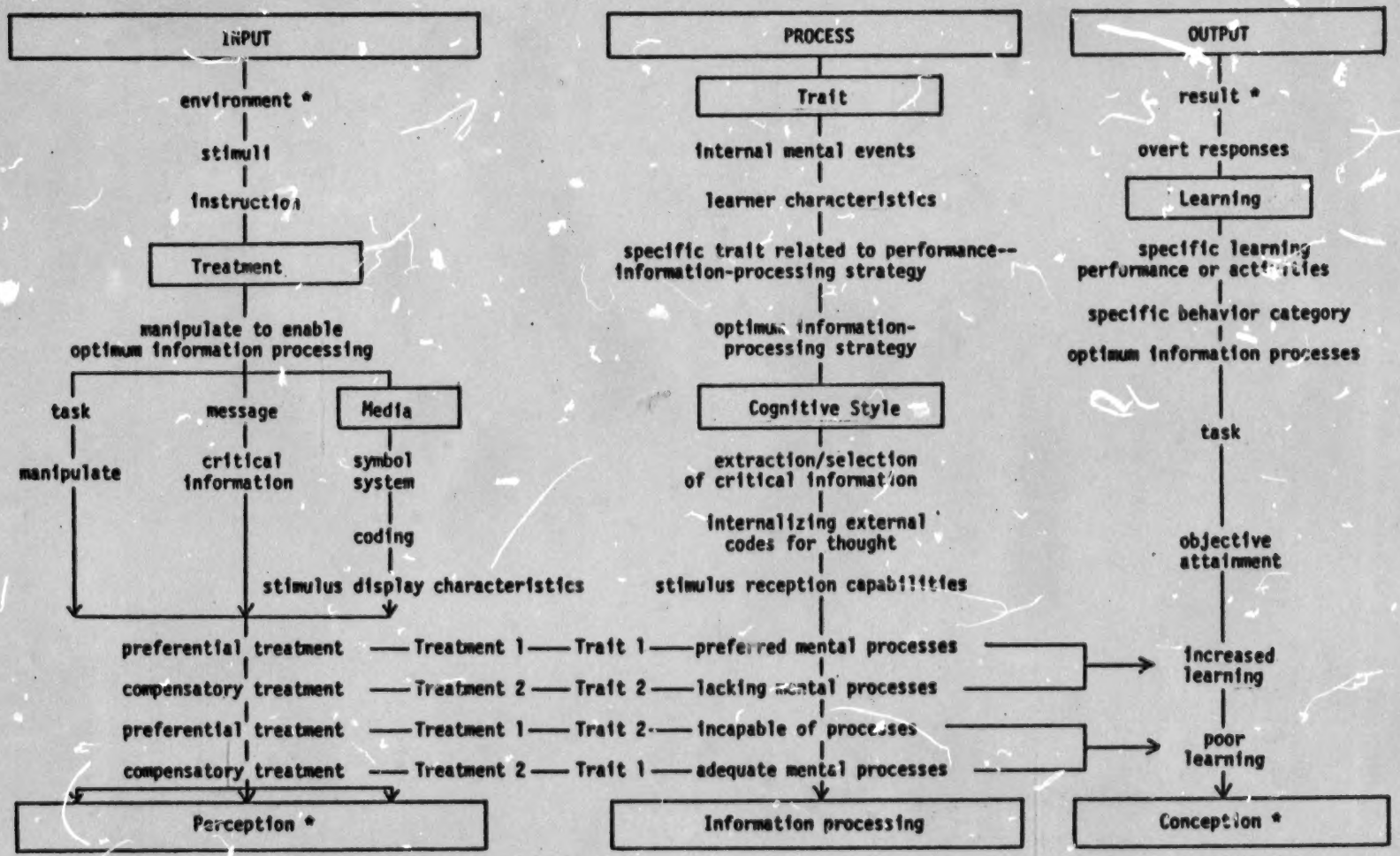
The objective of the research was to determine whether instructional treatments specifically designed to match identifiable learner characteristics which the literature has shown to be effective in differentiating conceptual learning can produce significantly better learning when a student receives instruction matched to these characteristics than when receiving mismatched instruction. The problem was to determine important learner-trait and instructional-treatment variables which contributed to differences in learning, and to find interactions between them. Such findings would enable (*a*) the design of treatments which would produce enhanced learning for specific learning traits, and (*b*) the prescriptive assignment of students to the appropriate treatment which matched their respective traits and which would enhance their learning.

Theoretical Framework

Theoretical Literature

The researcher synthesized a theoretical model of the relationships among the increasingly specific levels of the three areas of treatment design, learner processing style, and the resultant concept learning (Elliot, 1975).

The model was drawn from the work of Cronbach & Snow (1969), Snow (1970), Salomon (1972, 1974), Merrill (1971), Witkin et al. (1962), and Kagan (1965b). Figure 1 presents a summary of the main elements of the cited theories in terms of an input-process-output model. As the specificity increases among treatment, learning style, and concept learning, the possibility of correspondence and interaction among these three areas also increases. As the correspondence and interaction



Note.--* = terms which were not mentioned in the cited models, but which were logically inferred by the researcher to complete this model.

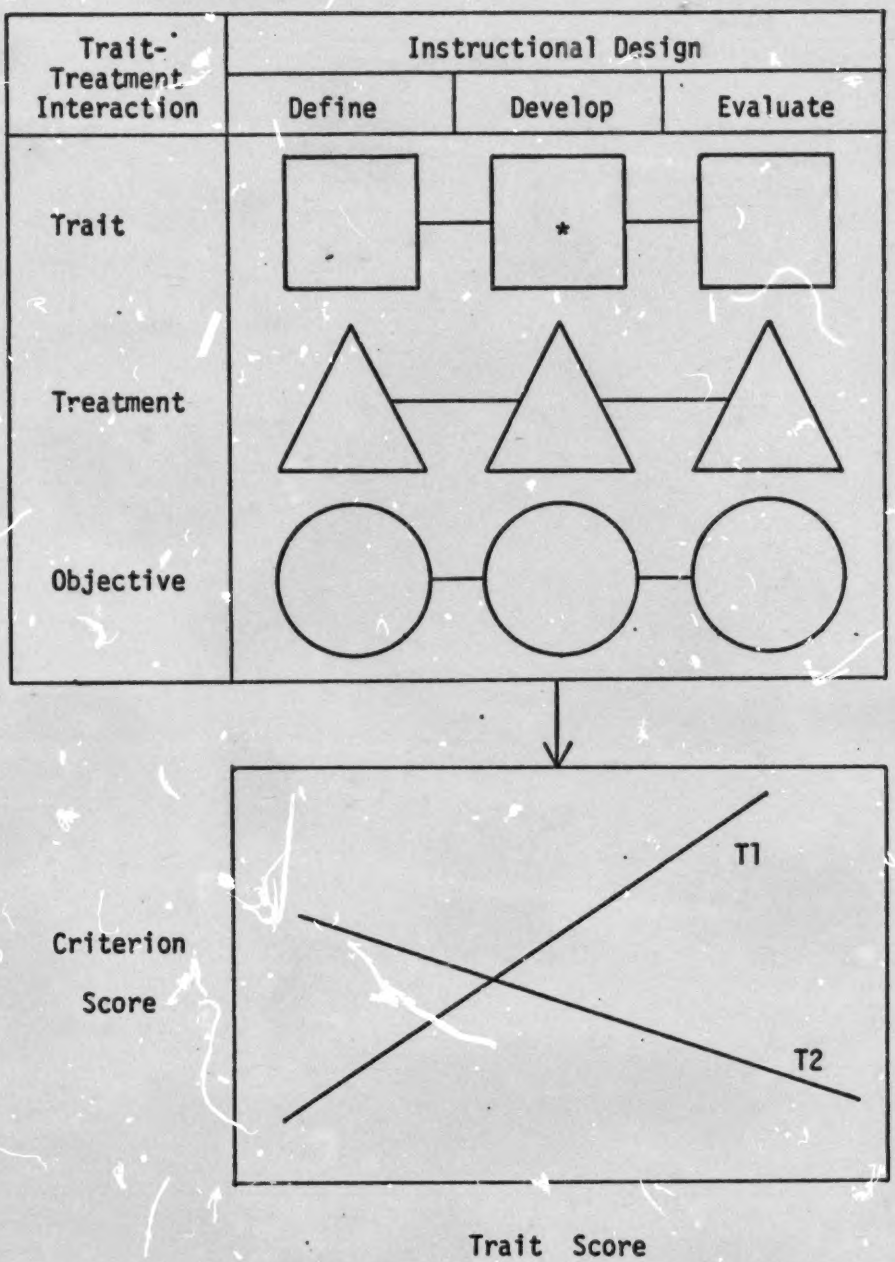
FIG. 1. Input-process-output model of trait-treatment interaction theories involving cognitive style and media.

among the areas increase, the possible amount of learning also increases.

Proposed Model

A general theoretical model for the combining of trait-treatment interaction theory and instructional design is presented symbolically in Figure 2. Each of the three major divisions of trait-treatment interaction (trait, treatment, and objective) is crossed with the three major steps of instructional design (define, develop, and evaluate). Traits are defined, selected, and then evaluated through cited research. Treatments and their objectives are defined, developed, and then evaluated empirically. The potential outcome of these procedures is indicated as charted regression lines showing differential achievement for students with differing learning characteristics when receiving different treatments.

More specifically, the assumption that cognitive styles are important variables in the maximization of individual learning, through the application of the learning theories cited (Elliot, 1975) and of the process of systematic instructional development, is demonstrated in Figure 3. The figure shows that learning might be optimized by using the learning characteristic of cognitive style as the basis of instructional design: (*a*) defining the information-processing mechanisms involved, (*b*) developing instructional materials with task information and media-element information related to the defined information-processing patterns, and (*c*) evaluating the information acquired in terms of the matching of the information structure of the instructional design and the information-processing mechanism. If the evaluation showed results which were not optimum, the results could be further



Note.--* = selected, not developed. T = treatment.

FIG. 2. General theoretical model. Combining trait-treatment interaction theory and instructional design.

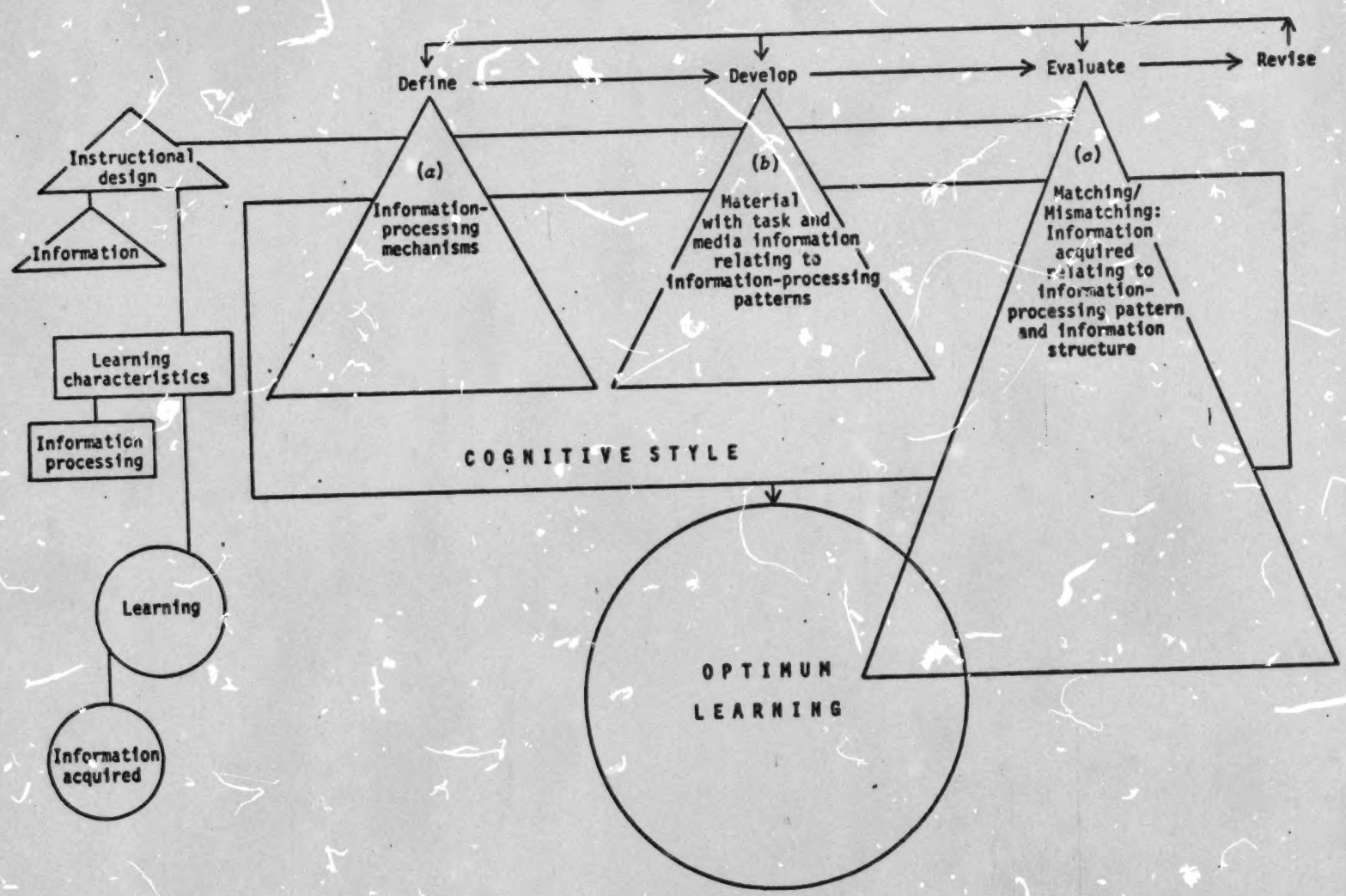


FIG. 3. Optimization of learning through the congruence of instructional design and the learning characteristic of cognitive style.

refined by revising the design procedures.

The validity of the model of optimization of learning was limited to the extent that:

(*a*) the cognitive style operated in learning in general, in concept learning, in the specific concept learning task, and in the mathematics subject matter;

(*b*) instruction in general and instructional design in particular can optimize concept learning;

(*c*) there was no overlap between one cognitive style and the opposite instructional design; and

(*d*) other individual differences did not operate substantially in the particular learning process.

Research Literature

In research involving the field-articulation dimension of cognitive style, field-independent *S*s have generally been found to perform better than field-dependent *S*s in a variety of learning situations, especially in concept learning (Frederick, 1967; Davis, 1967, 1973; Kirschenbaum, 1968; Wineman, 1971; Nelson, 1973). In research involving various cognitive styles, interactions have been found between traits and treatments (Kirschenbaum, 1968; Lazotte, 1969; Koran, 1969; Hester & Tagatz, 1971; Linker, 1972; Salomon, 1973; Marantz & Dowaliby, 1973; Witkin & Moore, 1974).

Hypotheses

On each of the criterion measures of concept learning:

1. There is an interaction of trait and treatment, favoring the field-dependent trait and the treatment intended to match the trait.

2. There is an interaction of trait and treatment, favoring the field-independent trait and the treatment intended to match the trait.

3. The scores obtained by *S*s of field-dependent trait who have received the treatment intended to match the trait are superior to scores obtained by *S*s of field-dependent trait who have received the treatment intended to match the field-independent trait.

4. The scores obtained by *S*s of field-dependent trait who have received the treatment intended to match the trait are superior to scores obtained by *S*s of field-dependent trait who have received the control treatment.

5. The scores obtained by *S*s of field-independent trait who have received the treatment intended to match the trait are superior to scores obtained by *S*s of field-independent trait who have received the treatment intended to match the field-dependent trait.

6. The scores obtained by *S*s of field-independent trait who have received the treatment intended to match the trait are superior to scores obtained by *S*s of field-independent trait who have received the control treatment.

7. The scores obtained by *S*s of field-independent trait who have received the treatment intended to match the trait are superior to scores obtained by *S*s of field-dependent trait who have received the treatment intended to match the field-independent trait.

Procedures

Determining Instructional Variables

The researcher synthesized a systematic research-based procedure for determining the variables used in the different instructional

designs which were intended to match the learning needs of *S*s classified by field-articulation and conceptual-tempo cognitive style traits. Procedures involved (*a*) learner analysis, (*b*) instructional analysis, and (*c*) instructional treatment design.

1. *Learner analysis.* Procedures of learner analysis were employed in order to determine individual cognitive traits which make a difference in learning, and which have potential for effective differentiations in the trait-treatment interaction study. The procedures involved (*a*) reading the literature in the pertinent areas, (*b*) systematic charting of the findings, (*c*) finding trends and recommendations for more specific areas to search, (*d*) extending the reading and charting to these more specific areas, (*e*) critiquing in detail the more specific literature, and (*f*) making generalizations for the individual trait variables which were tentatively selected at that point.

2. *Instructional analysis.* Procedures of instructional analysis were employed in order to find relationships in learning involving instructional variables and the selected individual traits. The procedures involved (*a*) searching the literature on concept learning, instructional variables, and cognitive style, with the emphasis on literature which crossed two or more of these topics; (*b*) presenting the findings in tables listing the variables and their sources; (*c*) proposing a matrix to relate each of the variables to each aspect of the selected individual learning traits; (*d*) analyzing the context to narrow down the instructional variables and to examine their role and importance in relation to each other; (*e*) reading and critiquing the literature on the more-closely narrowed-down list of instructional

variables; and (*f*) developing a theoretical model of the interaction of the constructs involved in order to demonstrate the detailed relationships of the individual traits and the instructional variables.

3. *Designing the appropriate instructional treatments.* Procedures for designing the appropriate instructional treatments to incorporate the determined matches of traits and treatments were then synthesized. The procedures involved (*a*) analyzing the subject matter, (*b*) consulting existing materials in order to verify compatibility with educational practice for generalizability of findings, (*c*) describing the informational content of the unit, (*d*) charting the content against possible instructional design elements selected for each trait, (*e*) developing the instructional treatments, and (*f*) producing the materials.

Pilot Study

In order to refine the selection of the independent variables, a pilot study was conducted. Separate experiments were run for two dimensions of cognitive style. The field-articulation experiments involved two trait variables, field-independence and field-dependence, as measured by the Children's Embedded Figures Test (Karp & Konstadt, 1971; Witkin et al., 1971). The conceptual-tempo experiments involved the two main trait variables, reflectivity and impulsivity, and a third non-classified trait, as measured by the Matching Familiar Figures Test (Kagan, 1965a).

In each experiment for each subject matter, there were three treatments, one which was intended to be matched to each of the two traits, and a control treatment having no instruction. Instruction was developed for a unit in geometry on polygons and a unit in language arts

on sentence combining. The compensatory instructional design for the field-dependent *S*s involved (*a*) the isolation of attributes by using distinctly different colors to highlight the specified attributes in the instruction, and (*b*) a sequential structure in the presentation of examples for each concept. The preferential design for the field-independent *S*s involved (*a*) no isolation of attributes, using the same color for all attributes, and (*b*) no logical structuring of examples, using randomly-drawn lots to determine the sequencing. The compensatory instructional design for impulsive *S*s used (*a*) advance organizers, (*b*) directed the *S*s to take their time to look carefully at each example, and (*c*) gave feedback after responses which explained each of the possible wrong answers. The preferential design for reflective *S*s gave (*a*) no advance organizers, (*b*) no directions to take time or care in looking at examples, and (*c*) feedback which reinforced the correct answer.

The experimental design, dependent variables, and population were similar in description to those for the main study, given below. The total *N* ranged from 22 to 27 in the four experiments. Data analysis generally was the same as for the main study. However, the conceptual tempo experiments used a 3 X 3 factorial design.

Detailed analysis of the findings of the pilot study for the field articulation experiments indicated that the selected matching strategies were incorrect and that an additional instructional variable needed to be included. The findings also showed that the conceptual tempo dimension of cognitive style could be eliminated from the main study because of the high correlation between field articulation and conceptual

tempo.

Main Study

The experimental design was a modification of the randomized control-group posttest-only design, using several tests in order to obtain data relevant to the stages of information processing within individuals of different traits who received different treatments.

The independent variables were (*a*) the two traits, field-independent and field-dependent cognitive styles, as measured by the Children's Embedded Figures Test, and (*b*) three treatments, one which was intended to be matched to each of the two traits, and a control treatment having no instruction. The instructional treatments for the geometry subject matter were designed, based on the development procedures and the findings of the pilot study. The treatment intended to match the field-independent cognitive style used (*a*) color highlighting, (*b*) structured example sequencing, and (*c*) high information density. The treatment intended to match the field-dependent cognitive style used (*a*) no highlighting, (*b*) random example sequencing, and (*c*) low information density.

The dependent variables were four criterion tests developed and validated by the researcher. Data obtained were the number of correct responses on each of these objective tests. The on-task test was interspersed with the instruction. The immediate posttest and the delayed-retention test were identical to each other, but the former was given in the same session with the instruction while the latter was given a week later. The delayed-transfer test used concepts parallel to those given in the instruction and was administered in the same

session with the delayed-retention test.

The population was third-grade students in the large suburban Baltimore County district. The total *N* ranged from 89 to 90 in the two sessions of criterion testing. All selections of *S*s and assignments to treatments were performed randomly.

Data were analyzed by a 2 X 3 factorial (traits X treatments) analysis of variance for each of the four criterion tests for each of the seven hypotheses, using an alpha level of .05. All *t* tests were one-tailed.

Findings

Analysis of variance (Table 1) found significant main effects for treatment 2, intended to match the field-dependence trait, over treatment 3, control, on the on-task test ($p < .001$); for treatment 1, intended to match the field-independence trait, over treatment 3 on the posttest ($p < .01$); and against treatment 3 on the delayed-transfer test ($p < .05$). The only consistency in these findings was in the poor performance of the *S*s who received the control treatment. A significant main effect for trait was found for the field-independence trait on the posttest ($p < .001$). This finding, however, did not recur.

Significant *t* statistics showed that two null hypotheses were rejected once and another twice (Table 2). Hypothesis 4 was rejected on the on-task test ($p < .01$), indicating that field-dependent *S*s who received the low information-density treatment intended to match their learning patterns achieved significantly higher concept learning than those who received the control treatment. Hypothesis 6 was rejected on both the on-task test ($p < .01$) and posttest ($p < .01$), indicating that

TABLE 1

Summary of Analyses of Variance for Criterion Tests

Source of Variation	*df*	*MS*	*F*
	On-Task Test		
Trait	1	11.378	1.779
Treatment	2	118.611	18.547***
Interaction	2	0.211	0.033
Within	84	6.395	
	Posttest		
Trait	1	94.044	17.623***
Treatment	2	38.811	7.273**
Interaction	2	3.011	0.564
Within	84	5.337	
	Delayed-Retention Test		
Trait	1	8.363	1.155
Treatment	2	13.374	1.847
Interaction	2	14.874	2.054
Within	83	7.242	
	Delayed-Transfer Test		
Trait	1	17.879	3.229
Treatment	2	17.635	3.184*
Interaction	2	6.047	1.092
Within	83	5.538	

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE 2

Significance of Difference

between Group Means by Hypothesis

Hypothesis and Cells compared [a]	Criterion Test							
	On-Task		Posttest		Delayed Retention [b]		Delayed Transfer	
	df	*t*	*df*	*t*	*df*	*t*	*df*	*t*
3. 2,2 and 2,1	28	1.112	28	1.662		--	27	1.061
4. 2,2 and 2,3	28	3.309**	28	0.460		--	25	0.379
5. 1,1 and 1,2	28	1.189	28	1.188		--	29	1.069
6. 1,1 and 1,3	28	3.559**	28	3.009**		--	28	1.482
7. 1,1 and 2,1	28	1.117	28	2.070*		--	31	0.403

[a] The first numeral for each cell is the trait (FI = 1, FD = 2). The second numeral is the treatment number.

[b] No *t* tests were run because the prerequisite significant *F* ratio was not obtained.

* $p < .05$

** $p < .01$

field-independent *Ss* who received the highlighted and structured treatment intended to match their learning patterns achieved significantly higher concept learning than those who received the control treatment. Hypothesis 7 was rejected on the posttest ($p < .05$), indicating that the highlighted and structured treatment produced significantly higher concept learning when given to field-independent *Ss* than field-dependent *Ss*.

Interpretation of Findings

The significant differences in scores between cells were interpreted to indicate that on the tests in which these results were found, there was successful matching of trait and treatment in comparison to the control treatment in three cases, and the opposite treatment in one case.

The undesired significant main effects for trait and treatment were interpreted in terms of their lack of recurrence and their inconsistency, respectively. The only consistency, the main effect disfavoring the control treatment, was interpreted in terms of the revision of the test items.

The lack of the desired interaction was attributed to the strength of the main effects and was described in terms of the factors which contributed to the inconsistent main effects.

Conclusions

The *t*-test data partially supported the theory that an instructional treatment can be specifically designed to match the cognitive style learning trait of students so as to produce significantly greater concept learning than when such design and matching do not occur. The

theory was supported for two treatments in geometry for two aspects of the field articulation dimension of cognitive style with third-grade *Ss*.

The data only supported the theory on two of four criterion tests, both of which occurred in temporal proximity to the administration of treatments. The theory was not supported on tests which were given a week later. The difference in findings for the different tests showed that short-term effects were subject to fading with the passage of time.

The significant *F* ratio which favored the field-independent trait on the posttest supported the general finding in the literature that field-independent *Ss* are superior in learning achievement to field-dependent *Ss*. However, the lack of persistence of this finding for the other tests suggested that the experimental conditions precluded the recurrence of this generally-occurring finding. To some extent, then, the use of differentiated treatments reduced the superiority of the field-independent trait.

The variety of significant *F* ratios for treatments on different tests did not demonstrate a general superiority for any treatment, but did show the general inferiority of the control treatment. Interpretations of these findings asserted that the effectiveness of a treatment varied not only with the learner trait, but with the test, and the nature of various interactions within the testing situation.

The lack of a significant *F* ratio for the interaction of trait and treatment may not be as important as the researcher originally thought because some specific interactions between trait and treatment occurred in the comparison of cell means of hypotheses 2 through 7.

A pilot study is a vital part of a trait-treatment interaction project because it can detect contrarieties which may not have been discovered in the process of conceptualizing the project. Also, a pilot study enables the data-based determination of needed revisions which can produce desired results which may not have occurred otherwise.

Recommendations

Theory

Trait-treatment interaction theory should further explore the effects of specific instructional variables on concept learning as related to specific cognitive styles. These explorations should attempt to determine different roles for different aspects of each of the selected variables.

There should be theoretical explications of the interrelationships of various cognitive styles with each other and with concept learning.

Specific theoretical models should be synthesized to explicate the interrelationships among specific aspects of the several dimensions of variables pertinent to the maximization of learning outcomes: learning traits, instruction, media, and content. The models should also include the possible sources of inefficient learning.

Theoretical models should be synthesized to attempt to explicate the conditions by which a compensatory treatment would inhibit cognitive development, such as by not requiring the learner to adapt to new situations.

Research

The total design of the main study should be expanded to include more instruction at various time intervals, such as daily and weekly, so

that the long-term effects of matching instructional designs to learning traits can be assessed.

Further research should be undertaken to determine and examine several theoretically- and research-based treatments which may be differentially-effective with field dependence and other cognitive styles which involve the lower end of a developmental continuum. The pursuit of treatments which differ for opposite cognitive styles may not be as worthwhile as the pursuit of various treatments for the *S*s who need compensatory treatments.

Trait-treatment interaction research should include multiple criterion measures in order to assess whether any significant findings appear or disappear under different conditions and at different times in relation to the instruction.

Instructional development projects and trait-treatment interaction studies should employ pilot research studies in order to obtain data (*a*) to determine if basic assumptions such as the matching of trait and treatment are accurate, and (*b*) to enable revisions which might not have been conceptualized without the data.

Practice

Practical implementation of the obtained research findings should await the results of further research which may find other trait or treatment variables to be more effective, or which may replicate the findings of this study.

Instructional designers and teachers should be aware of the possibility that their instruction can be concordant or discordant to a learner's cognitive style, potentially resulting in facilitation or

debilitation of concept learning. Efforts should be made to determine cognitive styles so that differentiated instruction can be designed and prescribed in accordance with research findings.

Instructional designers and teachers should be aware of the possibility that highlighting and structured sequencing may not necessarily be effective, and may even be detrimental for concept learning for certain students, such as those having a field-dependent cognitive style. Instructional procedures should be modified in accordance with research findings.

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